# Humphrey Matrix Perimetry in Optic Nerve and Chiasmal Disorders: Comparison with Humphrey SITA Standard 24-2

*Charles Q. Huang,*[1] *James Carolan,*[1] *Daniel Redline,*[1] *Parisa Taravati,*[2] *Kimberly R. Woodward,*[2] *Chris A. Johnson,*[3] *Michael Wall,*[2] *and John L. Keltner*[1,4]

**Purpose.** To compare the Humphrey Matrix 24-2 perimetry (Matrix; Carl Zeiss Meditec, Inc., Dublin, CA) with the standard automated perimetry Humphrey Visual Field Analyzer using SITA (Swedish Interactive Threshold Algorithm) program 24-2 (SAP; Carl Zeiss Meditec, Inc.) in neuro-ophthalmic disorders affecting the optic nerve and chiasm.

**Methods.** Matrix and SAP were performed on 93 patients with neuro-ophthalmic disorders affecting the optic nerve and optic chiasm. Three readers compared the total and pattern deviation probability plots and judged the similarity and the extent of the visual field defects. The sensitivity and specificity of both perimeters were calculated.

**Results.** Concordance was good in 61%, fair in 30%, and poor in 9% of the total deviation plots. For the pattern deviation, concordance was good in 52%, fair in 34%, and poor in 14%. The extent of field loss was equal in 50%, 23% more extensive with Matrix, and 27% more extensive with SAP for total deviation plots. For the pattern deviation, the extent was equal in 47%, 20% more extensive with Matrix and 33% more extensive with SAP. The sensitivity for detecting defects was 84% (SAP) and 77% (Matrix) for total deviation and 80% (SAP) and 79% (Matrix) for pattern deviation (no significant difference, $P > 0.05$). The specificity was 84% (SAP) and 86% (Matrix) for total deviation and 68% (SAP) and 74% (Matrix) for pattern deviation (no significant difference, $P > 0.05$).

**Conclusions.** The new Humphrey Matrix 24-2 testing strategy provides a visual field testing method for optic nerve and chiasmal disorders that has fair to good concordance with the Humphrey SITA Standard 24-2 program. Both tests have similar sensitivity and specificity. (*Invest Ophthalmol Vis Sci.* 2008;49: 917–923) DOI:10.1167/iovs.07-0241

From the Departments of [1]Ophthalmology and Vision Science and [4]Neurology and Neurological Surgery, University of California Davis School of Medicine, Sacramento, California; the [2]Department of Ophthalmology, University of Iowa Hospitals and Clinics, Iowa City, Iowa; and [3]Discoveries in Sight, Devers Eye Institute, Portland, Oregon.

Supported by a research grant from Welch-Allyn, Inc., and by an unrestricted grant to the Department of Ophthalmology, University of California Davis, from Research to Prevent Blindness.

Submitted for publication February 24, 2007; revised August 7 and September 6, 2007; accepted January 11, 2008.

Disclosure: **C.Q. Huang**, Welch-Allyn (F); **J. Carolan**, Welch-Allyn (F); **D. Redline**, Welch-Allyn (F); **P. Taravati**, Welch-Allyn (F); **K.R. Woodward**, Welch-Allyn (F); **C.A. Johnson**, Welch-Allyn (C, F); **M. Wall**, Welch-Allyn (F); **J.L. Keltner**, Welch-Allyn (F)

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be marked "*advertisement*" in accordance with 18 U.S.C. §1734 solely to indicate this fact.

Corresponding author: John L. Keltner, Department of Ophthalmology and Vision Science, University of California, Davis School of Medicine, 4860 Y Street, Suite 2400, Sacramento, CA 95817; jlkeltner@ucdavis.edu.

The frequency-doubling effect occurs when a low-spatial-frequency sinusoidal grating undergoes high temporal frequency counterphase flicker, giving the appearance of a spatial frequency twice that of the actual spatial frequency. Frequency-doubling technology (FDT) is based on the assumption that the low spatial frequency of the grating in combination with the high temporal frequency of the counterphase flicker of the stimulus preferentially stimulates cells of the magnocellular (M cell) layer of the lateral geniculate nucleus, which are believed to be primarily involved in the detection of motion and rapid flicker.[1] The frequency-doubling effect has been attributed to $M_y$ cells, which constitute only a small fraction of the total number of M cells, although recent reports suggest that this phenomenon may involve the interaction of many types of neural elements.[2] Because the M-cell system has fewer fibers, it may have less redundancy. If there is less redundancy, there should be less tolerance to optic nerve damage, and visual field loss should evolve early in the course of optic nerve damage.[3] Therefore, it has been hypothesized that testing for the detection of the frequency-doubling effect should be a very sensitive method of identifying early visual field loss.

FDT perimetry was developed primarily for screening patients for evidence of glaucomatous damage to the optic nerve. It has been validated thoroughly for this purpose in normal subjects and in those with glaucoma.[4,5] As a screening device for glaucoma and other ocular and neurologic disorders, the sensitivity of FDT perimetry is similar to or better than that of the Humphrey Field Analyzer (all Humphrey equipment is manufactured by Carl Zeiss Meditec, Inc., Dublin, CA), and its specificity is excellent.[2,4–7] FDT perimetry also appears to be more sensitive in detecting visual dysfunction in the uninvolved hemifield in patients with nonarteritic ischemic optic neuropathy.[8] Recently, FDT has been found to be potentially more sensitive than standard automated perimetry in detecting visual field defects in resolved optic neuritis.[9]

Patients with neuro-ophthalmic disorders may have very different visual field defect morphology than patients with glaucoma. For example, patients with optic neuritis, anterior ischemic optic neuropathy, or compressive optic neuropathies may have centrocecal loss, in addition to arcuate nerve fiber bundle–like defects. In their study, Wall et al.[10] demonstrated that C-20 FDT perimetry (ver. 2.60; Welch-Allyn, Skaneateles, NY) has sensitivity and specificity similar to that of standard automated perimetry (SAP) for detection of visual field loss in patients with optic neuropathies. However, with C-20 FDT perimetry, hemianopic visual field defects sometimes failed to respect the vertical midline. One explanation postulated was that light from the stimulus scatters from the nonseeing into the seeing hemifield, either because the stimulus is placed too close to the vertical meridian or because the patient shifts fixation. A second problem that is more difficult to remedy was the presence of scattered abnormal test locations obscuring the homonymous hemianopic character of the defect. The reason for the presence of this probability plot noise was unclear. Theoretically, both of these problems would be re-

solved with the FDT by increasing the number of stimuli from 17 to 55, decreasing stimulus size from 10° × 10° to 5° × 5°, and offsetting the stimulus by 3°, with respect to the vertical meridian. These changes are incorporated into the second generation of FDT perimetry, also known as Humphrey Matrix 24-2 (Matrix).[11] These changes make Matrix more comparable to the SAP Humphrey SITA Standard 24-2, which is used as the test of choice in neuro-ophthalmology clinics.

The objective of this study was to compare the Matrix with SAP in detecting visual field defects in patients with optic nerve and chiasmal disorders. The similarity and extent of field defects detected by both perimeters was compared. Sensitivity and specificity for each perimeter was also determined. The Matrix perimetry of patients with retrochiasmal defects will be presented in a separate article.

## Methods

### Subjects

The University of California, Davis, and University of Iowa Institutional Review Boards approved the protocol, which adhered to the tenets of the Declaration of Helsinki, and participants signed informed consent documents before testing. The medical records database from 1999 to 2002 was queried by using ICD-9 codes for visual loss, brain neoplasm, optic nerve drusen, pituitary tumor, anterior ischemic optic neuropathy, and cerebrovascular accident. One hundred and nine patients with visual field loss secondary to a neuro-ophthalmic disorder gave informed consent to participate in the study. Patients were seen either at the University of California, Davis, Neuro-ophthalmology Clinic or the University of Iowa Neuro-Ophthalmology Clinic. All subjects underwent neuro-ophthalmic examination, including intraocular pressure measurement. Patients had lesions of the optic nerve or chiasm, documented by magnetic resonance imaging or computed tomography, or they had objective evidence of an optic neuropathy. Optic neuropathy was defined as a decline in vision, color perception, or visual fields along with evidence of optic nerve swelling, and/or atrophic pallor. This optic neuropathy could be secondary to ischemia, compressive or infiltrative lesions, trauma, toxins or nutritional deficiencies, hereditary or congenital optic neuropathies, or increased intracranial pressure. The default visual field test for new patients in the neuro-ophthalmology clinic is Humphrey Visual Field Analyzer using SITA Standard 24-2 (SAP). The subjects' charts were reviewed for stable visual field loss, reliable perimetry, and to exclude confounding diagnoses such as glaucoma or retinal disease. Patients with extensive diabetic retinopathy and/or previous laser treatments were also excluded. During the course of the study, some patients with prior visual field loss demonstrated normal visual fields. These patients were not excluded from the study. All patients had perimetry with both Humphrey SITA Standard 24-2 and Humphrey Matrix 24-2 performed in both eyes on the same day, with the exception of 11 patients who had one eye tested due to poor vision in the other eye. A total of 207 eyes were tested in the initial 109 patients. All patients underwent both SAP and Matrix testing. These fields were reviewed for reliability to exclude unreliable fields. Reliability criteria used consisted of a limit of 15% for false positives, 33% for false negatives and fixation losses for the SAP, and 33% for all three reliability indices for the Matrix. These percentages are the internal reliability thresholds used by the Humphrey SITA Standard 24-2 and Matrix 24-2. Healthy eyes of patients with unilateral neuro-ophthalmic disorders were also excluded. Only one eye was selected in patients with bilateral disease. If these patients had reliable fields from both eyes, the selection was based on alternating the better eye and worse eye based on the SAP mean deviation. After excluding unreliable visual fields, the final patient population consisted of one eye from 93 patients. Table 1 summarizes the characteristics of the patient sample.

To calculate the specificity of both perimeters, we recruited an additional 50 normal subjects by placing phone calls to individuals at random from the Iowa City phone book and by placing advertisements in a hospital newsletter. Normal subjects were included if they had (1) no history of eye disease except refractive error (no more optical correction than 5 D of sphere or 3 D of cylinder); (2) no history of diabetes mellitus or systemic arterial hypertension; (3) no history of ophthalmic surgery; and (4) a normal ophthalmic examination including 20/25 or better corrected Snellen acuity. The included subjects had either undergone a complete eye examination within 12 months before the study or were examined by an ophthalmologist on the day of testing to ensure normal ocular health. Normal subjects had a randomly chosen eye tested with both SAP and Matrix. The normal subject group's mean age was 57 years (range, 45–73).

**Table 1.** Patient Characteristics

| | |
|---|---|
| Patients (*n*) | 93 |
| Eyes tested (*n*) | 93 |
| Mean age, y (range) | 47 (19–84) |
| Men: Women (*n*) | 39:54 |
| Tested eye, *n* (OD:OS) | 45:48 |
| Diagnosis | |
| Anterior ischemic optic neuropathy | 20 |
| Idiopathic intracranial hypertension | 17 |
| Optic neuritis | 14 |
| Tumor/compressive lesions of the optic nerve (i.e., meningiomas) | 12 |
| Tumor/compressive lesions of the optic chiasm (i.e., pituitary adenomas, craniopharingiomas) | 11 |
| Optic nerve drusen | 9 |
| Other optic neuropathies | 6 |
| Papilledema (Chiari malformation) | 2 |
| Autoimmune optic neuropathies | 1 |
| Congenital (hypoplastic disc) | 1 |

### Perimeters

SAP was performed with the Humphrey Visual Field Analyzer SITA Standard 24-2 perimeter, according to the manufacturer's recommendations. We used a 4-mm$^2$ size III stimulus (0.43°) on a uniform background (31.5 apostilbs, 10 cd/m$^2$). The differential light sensitivity threshold was found at each test location. The patients' appropriate near correction was used. Rest breaks were allowed when requested. The SITA Standard 24-2 program presents stimuli on a 6° spaced grid encompassing the central 21° of the visual field and horizontally and vertically bracketing fixation.

Patients were alternated to receive Humphrey Matrix 24-2 perimetry either before or after SAP. A 15-minute rest period between the tests was given in an attempt to diminish the fatigue effect. Testing was performed in a darkened room (the test can be taken with normal room lighting) using the Matrix device (24-2 test, ver. 3.0). This protocol determines the minimum contrast necessary to detect a 0.5-cyc/deg stimulus undergoing an 18-Hz counterphase flicker for each of the 55 target locations in the display. This pattern has 13 stimulus test locations in each temporal quadrant, 14 in each nasal quadrant, and 1 in the central location. Each stimulus location spans approximately 5° in the vertical dimension and 5° in the horizontal dimension. The Matrix also includes a central 1° square stationary central fixation target. This provides a test area of approximately 48° × 48° or a 24° radius surrounding fixation. Stimulus presentation time is 720 ms. During the first 160 ms, stimulus contrast is increased gradually from 0. If the stimulus is not seen, the display shows this maximum contrast for the trial for a duration of 400 ms. The contrast is then gradually decreased to 0 during the final 160 ms. If the stimulus is seen, the stimulus presentation is interrupted when the response button is pushed. After each stimulus presentation, there is a variable random interval of 0 to 500 ms to minimize anticipation by the patient. Responses that fall outside a 1000-ms response window are not counted. Determination of the minimum contrast necessary to detect the stimulus at a particular location is accomplished by means of a

**TABLE 2.** Comparison of SAP and Matrix by Similarity and Extent of Visual Field Loss for Anterior and Chiasmal Defects

| | Total Deviation | Pattern Deviation |
|---|---|---|
| Similarity | | |
| Good | 57 (61) | 48 (52) |
| Fair | 28 (30) | 32 (34) |
| Poor | 8 (9) | 13 (14) |
| Extent | | |
| Same | 47 (50) | 44 (47) |
| SAP greater | 25 (27) | 31 (33) |
| Matrix greater | 21 (23) | 18 (20) |

$N = 93$. Percentage of total group is in parentheses. Greater extent was defined as SAP or Matrix detecting five or more abnormal test locations at $P < 0.5\%$.

ZEST (zippy estimation of sequential threshold) estimation procedure.[11] Total test time for the Matrix is approximately 5 minutes per eye.

## Analysis of Visual Field Defects

Three trained readers (JLK, MW, JC) analyzed data from the patients' total deviation and pattern deviation probability plots for the two testing modalities. The readers examined the visual fields, first individually and then in a joint session with the two other readers. Each reader compared the similarity of the topographic pattern of the visual field defects for both the total deviation and the pattern deviation probability plots. The similarity of the topographic pattern was categorized as "good" when the same type of defect was present in both, "fair" when the defects were different but some overlap was present, and "poor" when the areas of visual loss did not coincide.

The mean deviation (MD) and pattern standard deviation (PSD) for both perimeters were also compared, to assess their degree of correlation. The Spearman coefficient (rho) was calculated and used to examine this correlation.

The extent of the total and pattern deviation plot defects from the two testing modalities was also compared. A particular perimeter was considered to detect more extensive field loss if it identified five or more abnormal test locations at $P < 0.5\%$ than the other perimeter. Otherwise, the extent of visual field loss detected was scored as the same for both perimeters.

The three readers then met in joint session, and the evaluations for each field were reviewed. If there was any disagreement between scores for a particular visual field, the field was reviewed and the scores given to that particular perimetric examination were adjudicated until there was a consensus decision. This method of analyzing, categorizing, and grading visual fields has been used and validated extensively in previous studies.[10,12–16]

The sensitivity and specificity of both perimeters were also calculated. The sensitivity was the percentage of patients who met criteria for a visual field defect, and specificity was the percentage of normal subjects with normal visual fields. The $\chi^2$ test was used to test for differences between groups. To qualify as an abnormal visual field in the sensitivity and specificity calculation, a visual field defect required at least three adjacent abnormal points on the probability plot at $P < 0.05$ or two adjacent points with one abnormal point at $P < 0.01$, to be present in a clinically suspicious area. This definition of abnormality is similar to the previous classifications systems for neuro-ophthalmic visual field defects used in C-20 FDT perimetry[10] and in the Optic Neuritis Treatment Trial.[12,15,16] The definition is in contrast to the methods of visual field classifications used in glaucoma classification methods where disease is found in the hemifield region. In visual field classification for glaucoma, generally the hemifield is considered and this is the basis of the classification system used in the Ocular Hypertension Treatment Study (OHTS) and the methodology of Anderson and Patella.[13,14,17] Unlike, the OHTS, we did not accept a single abnormal test location as a visual field defect in one eye because one abnormal test location might well be expected by chance alone in these neuro-ophthalmic disorders. The gold standard for classification of disease was the patient's clinical diagnosis.

Statistical calculations were performed with commercial software (Statistical Analysis Software; NCSS, Kaysville, UT), and $P < 0.05$ was considered statistically significant.

## RESULTS

After excluding unreliable visual fields and randomly selecting one eye per patient, 93 reliable fields from 93 patients were analyzed. The mean test duration for SAP and Matrix were 361 and 320 seconds, respectively; Matrix's test duration was 11% less than that of SAP ($P < 0.001$, Mann-Whitney U test). The mean SAP mean deviation and pattern standard deviation was −8.0 dB (SD ±9.0) and 5.7 dB (SD ±4.4), respectively. For the Matrix, the mean was −8.0 dB (SD ±7.6) for mean deviation and 5.2 dB (SD ±2.6).

Table 2 summarizes the similarity and extent of field loss between the SAP and the Matrix in all 93 patients. Table 3 compares the similarity and extent by diagnostic groups. Only diagnoses with more than 10 patients are included in this table.

A comparison of visual fields based on the mean deviation showed a significant correlation between SAP and Matrix (Spearman $\rho = 0.82$; $P < 0.001$; Fig. 1) Similarly, there was a significant correlation between both SAP and Matrix PSD (Spearman $\rho = 0.82$; $P < 0.001$; Fig. 2).

Table 4 shows the number of patients and normal subjects who had normal or abnormal visual fields. The overall specificity and sensitivity of both SAP and Matrix based on the

**TABLE 3.** Comparison of SAP and Matrix by Similarity and Extent of Visual Field Loss for Different Diagnostic Categories of Optic Neuropathies and Chiasmal Disorders

| | AION (20) | | IIH (17) | | ON (14) | | T/C (12) | | Chiasm (11) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TD | PD | TD | PD | TD | PD | TD | PD | TD | PD |
| Similarity | | | | | | | | | | |
| Good | 85 | 50 | 53 | 47 | 50 | 50 | 58 | 67 | 45 | 45 |
| Fair | 10 | 20 | 41 | 47 | 36 | 43 | 33 | 25 | 45 | 45 |
| Poor | 5 | 30 | 6 | 6 | 14 | 7 | 8 | 8 | 9 | 9 |
| Extent | | | | | | | | | | |
| Same | 65 | 40 | 35 | 47 | 50 | 50 | 50 | 58 | 36 | 45 |
| SAP greater | 25 | 55 | 24 | 12 | 21 | 36 | 33 | 42 | 36 | 27 |
| Matrix greater | 10 | 5 | 41 | 41 | 29 | 14 | 17 | 0 | 27 | 27 |

Data are percentage of subjects in each diagnostic category. AION, anterior ischemic optic neuropathy; IIH, idiopathic intracranial hypertension; ON, optic neuritis; T/C, tumor/compressive optic neuropathy; chiasm, tumors of chiasm; TD, total deviation plots; PD, pattern deviation plots.

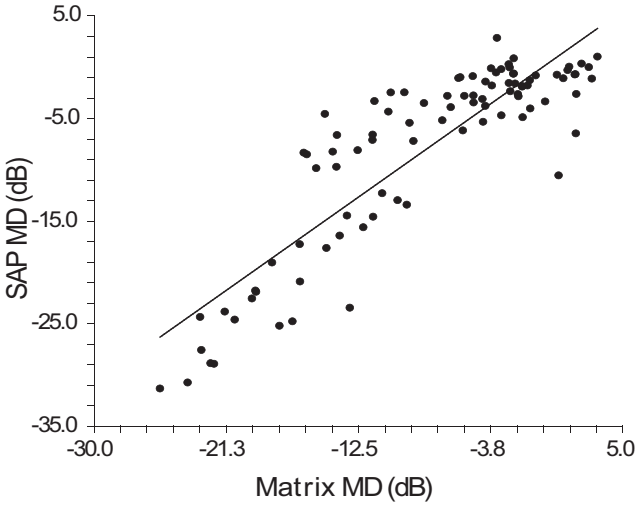


**FIGURE 1.** Scatterplot demonstrating the correlation between mean deviation (MD) obtained with SAP and Matrix (Spearman $\rho = 0.82$; $P < 0.001$).

results in Table 4, and the values are shown in Table 5. There was no statistically significant difference in sensitivity and specificity between both perimeters in terms of the total and pattern deviation plots ($\chi^2$, $P > 0.05$).

The sensitivity of both perimeters for each diagnostic category was also analyzed, and the results are shown in Table 6. Figures 3, 4, 5, and 6 show examples of our findings for the SAP and Matrix.

## DISCUSSION

Frequency-doubling technology perimetry was initially developed as a method of detecting early visual field loss by attempting to isolate the $M_y$ subset of retinal M ganglion cells. This subset was selected for specific stimulation, because it comprises only a small portion of the total retinal M ganglion cells. If there is less redundancy, there should be less tolerance to optic nerve damage, and visual field loss should evolve early in the course of optic nerve damage. In a previous study of FDT, Wall et al.[10] and White et al.[2] concluded that it is unlikely that the M cell is psychophysically isolated by FDT perimetry. If the M cell is indeed isolated by frequency doubling, it did not appear to result in an increase in the sensitivity of FDT perimetry.[2] In our study comparing the second generation FDT Humphrey Matrix and SAP, we obtained similar results. For a particular perimetry modality to be more sensitive to visual field loss than another modality, it follows that it would have to detect more extensive field loss for a given deficit. For our study, we required that a perimeter detect five or more abnormal test locations at the $P < 0.5\%$ level that the other perimeter did not detect, to classify the result as a more extensive field loss. The extent of field loss as seen on total deviation probability plots was more extensive with SAP in 25 (27%) of the 93 eyes studied and was equal in 47 (50%) eyes. In only 21 (23%) of the 93 eyes was the extent of visual field loss on total deviation probability plots more extensive with Matrix. Similar results were obtained for the pattern deviation probability plots. The extent of the defect as seen on pattern deviation probability plots was more extensive with SAP in 31 (33%) eyes and equal in 44 (47%) eyes. In only 18 (20%) eyes was the extent of visual field loss on pattern deviation probability plots more extensive with Matrix.

Examining each of the diagnostic categories separately, SAP also showed more extensive visual defects with the exception of idiopathic intracranial hypertension and the total deviation plots in optic neuritis (Table 3). In a previous study using earlier generation of FDT perimetry that tests 19 locations, Girkin et al.[8] found that FDT detected more extensive visual field defects than SAP in the uninvolved hemifield of patients with AION. In our study, one would expect that Matrix, with 55 test locations, would also detect more extensive defects; however, our results did not meet these expectations (Table 3). A possible explanation is that in Girkin et al.,[8] only patients who demonstrated altitudinal defects on SAP were included. In our study, all types of visual field defects were included in the patients with AION. Only 5 of the 20 patients with AION had

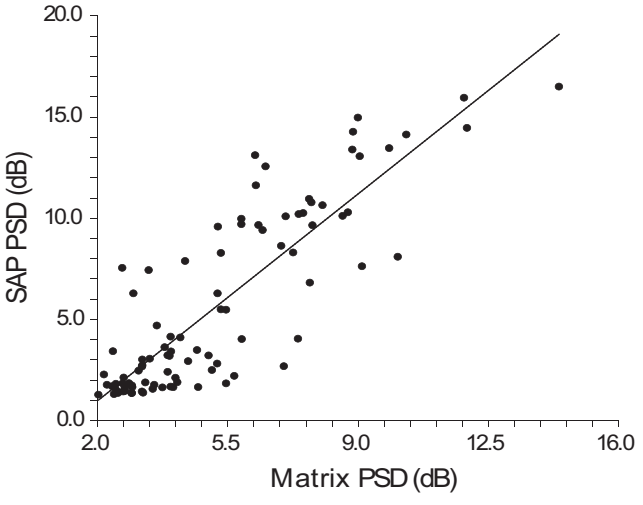


**FIGURE 2.** Scatterplot demonstrating the correlation between pattern SD (PSD) obtained with SAP and Matrix (Spearman $\rho = 0.82$; $P < 0.001$).

**TABLE 4.** Detection of Visual Field Abnormalities in Patients and Normal Subjects by SAP and Matrix

| | Total Deviation | | Pattern Deviation | |
|---|---|---|---|---|
| | SAP | Matrix | SAP | Matrix |
| Patients (all diagnoses) | | | | |
| Abnormal visual field | 78 (84) | 72 (77) | 74 (80) | 73 (78) |
| Normal visual fields | 15 (16) | 21 (23) | 19 (20) | 20 (22) |
| Normal subjects | | | | |
| Abnormal visual field | 8 (16) | 7 (14) | 16 (32) | 13 (26) |
| Normal visual fields | 42 (84) | 43 (86) | 34 (68) | 37 (74) |

Data are the number in each category, with the percentage of the total group in parentheses.

**TABLE 5.** Sensitivity and Specificity of SAP and Matrix Perimetry in the Detection of Anterior and Chiasmal Defects

| | SAP | Matrix | *P* |
|---|---|---|---|
| Total deviation | | | |
| Sensitivity | 84 | 77 | 0.27 |
| Specificity | 84 | 86 | |
| Pattern deviation | | | |
| Sensitivity | 80 | 79 | 0.86 |
| Specificity | 68 | 74 | |

Data are percentages of sensitivity and specificity. Probabilities are by $\chi^2$ testing for differences between the perimeters.

**TABLE 6.** Sensitivity of SAP and Matrix by Diagnostic Categories

| Diagnostic Category | SAP | | Matrix | |
|---|---|---|---|---|
| | Total Deviation | Pattern Deviation | Total Deviation | Pattern Deviation |
| AION | 100 | 90 | 86 | 75 |
| IIH | 59 | 53 | 71 | 71 |
| Optic neuritis | 100 | 79 | 86 | 86 |
| Tumor/compressive | 67 | 83 | 67 | 67 |
| Chiasm | 82 | 91 | 73 | 91 |
| Drusen | 89 | 89 | 78 | 78 |

Data are sensitivity percentages. AION, anterior ischemic optic neuropathy; IIH, idiopathic intracranial hypertension; chiasm, tumors of chiasm; drusen, optic nerve drusen.

altitudinal defects on SAP and 2 of the 5 had more extensive defects in the uninvolved field. Because of our small number of patients with altitudinal defects, we are unable to determine whether Matrix can detect more extensive defects in the uninvolved hemifields.

Similar to a recent study using Matrix in patients with optic neuritis,[9] this study showed that the MD and PSD for both perimeters had a statistically significant correlation (Figs. 1, 2) However, for patients with neuro-ophthalmic disorders, the correlation of the location or pattern of the visual field deficit is more important than the degree of MD or PSD correlation or the extent of the visual field deficit. Our group found that despite the changes made for Matrix, the congruity of field defects detected by Matrix perimetry for patients with optic nerve and chiasmal neuro-ophthalmic disorders is fair to good when compared with SAP. We found that examining our overall patient population with neuro-ophthalmic disorders, for the total deviation probability plots, 61% had good, 30% had fair, and 9% had poor correlation of field defects. The similarity in field defects between the Matrix and SAP was worse for the pattern deviation probability plots than for the total deviation probability plots. For the pattern deviation probability plots, 52% had good, 34% had fair, and 14% had poor correlation of field defects. In examination of individual diagnostic groups (Table 3), the similarity between Matrix and SAP field loss appeared to be better for the total deviation plots of patients with AION than for patients with other diagnoses. Other diagnostic groups had similar percentages of good, fair, and poor correlation of field loss when compared with the combined patient groups. However, we must use caution against making any definitive statement, because our sample numbers are small.

It is unclear what accounts for this difference in correlation of field loss between SAP and Matrix. Whether or not this fair correlation is the result of the scattered abnormal test locations described in the paper by Wall et al.[10] is difficult to determine.

Wall et al.[10] concluded that C-20 FDT perimetry (ver. 2.60; Welch-Allyn) was similar in sensitivity and specificity to SAP in patients with both anterior pathway and retrochiasmal neuro-ophthalmic disorders. In our study, the overall sensitivity in detecting visual field defects was good and comparable for both Matrix and SAP (Table 5). Matrix appeared to have comparable sensitivity to SAP in individual diagnostic categories. Unlike the recent study by Sakai et al.[9] that showed Matrix to be potentially more sensitive than SAP in detecting defects in resolved optic neuritis, our study did not find this increase in sensitivity. One explanation to account for overall decreased sensitivity for both perimeters is that we did not exclude patients who had previously abnormal fields but presented with normal fields during the study. Since the objective of our study was to compare two

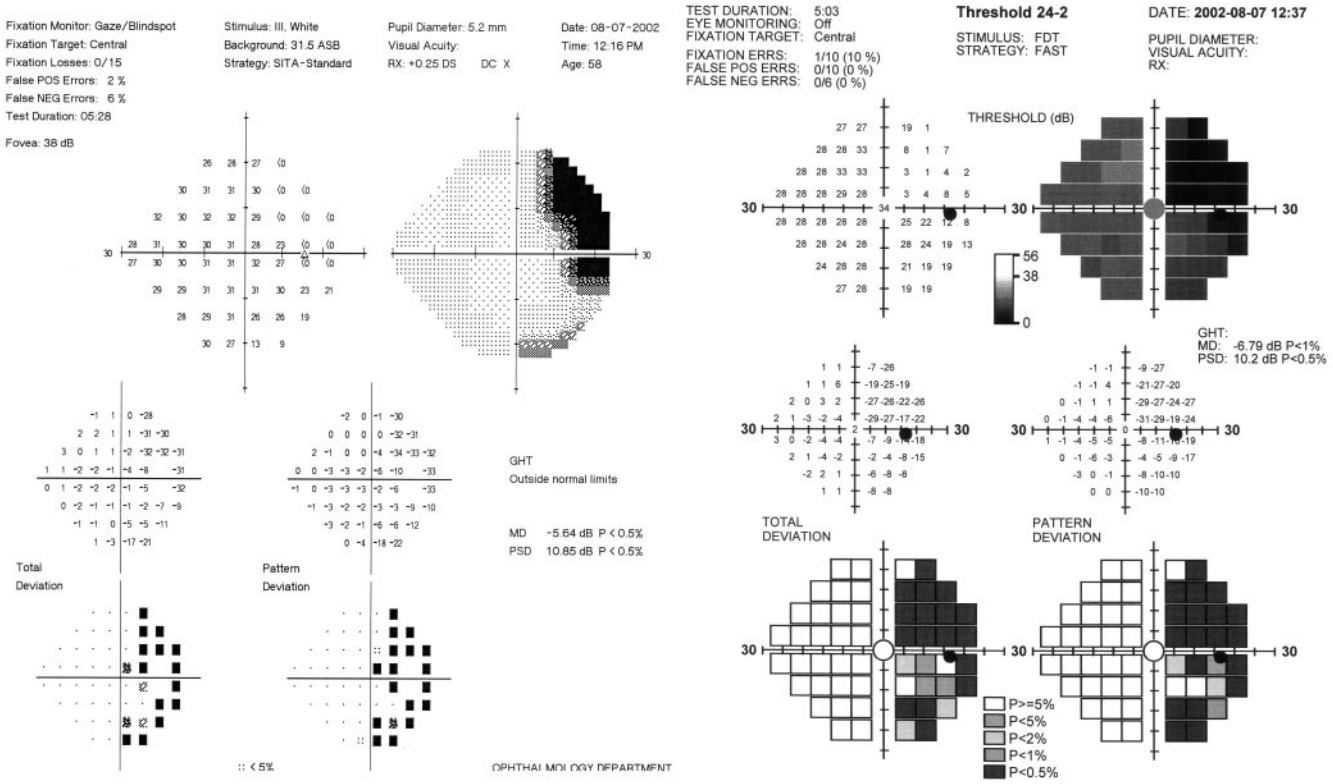


**FIGURE 3.** A 58-year-old subject with meningioma in the right eye. The correlation score for both the total deviation and pattern deviation probability plots was good. An equivalent amount of visual field loss was demonstrated by both tests for the total deviation and pattern deviation probability plots.

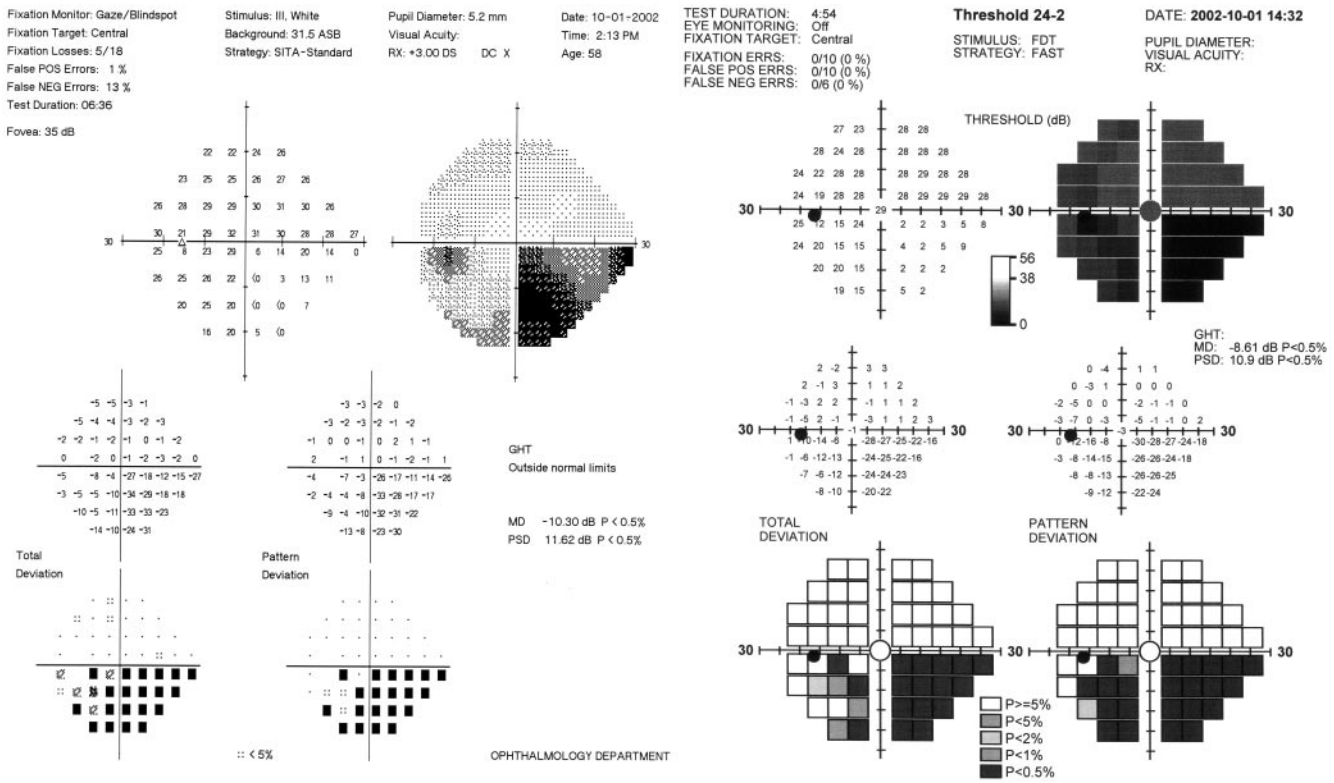


**FIGURE 4.** A 58-year-old subject with AION in the left eye. The correlation score for both the total deviation and pattern deviation probability plots was good. An equivalent amount of visual field loss was demonstrated by both tests for the total deviation and pattern deviation probability plots.

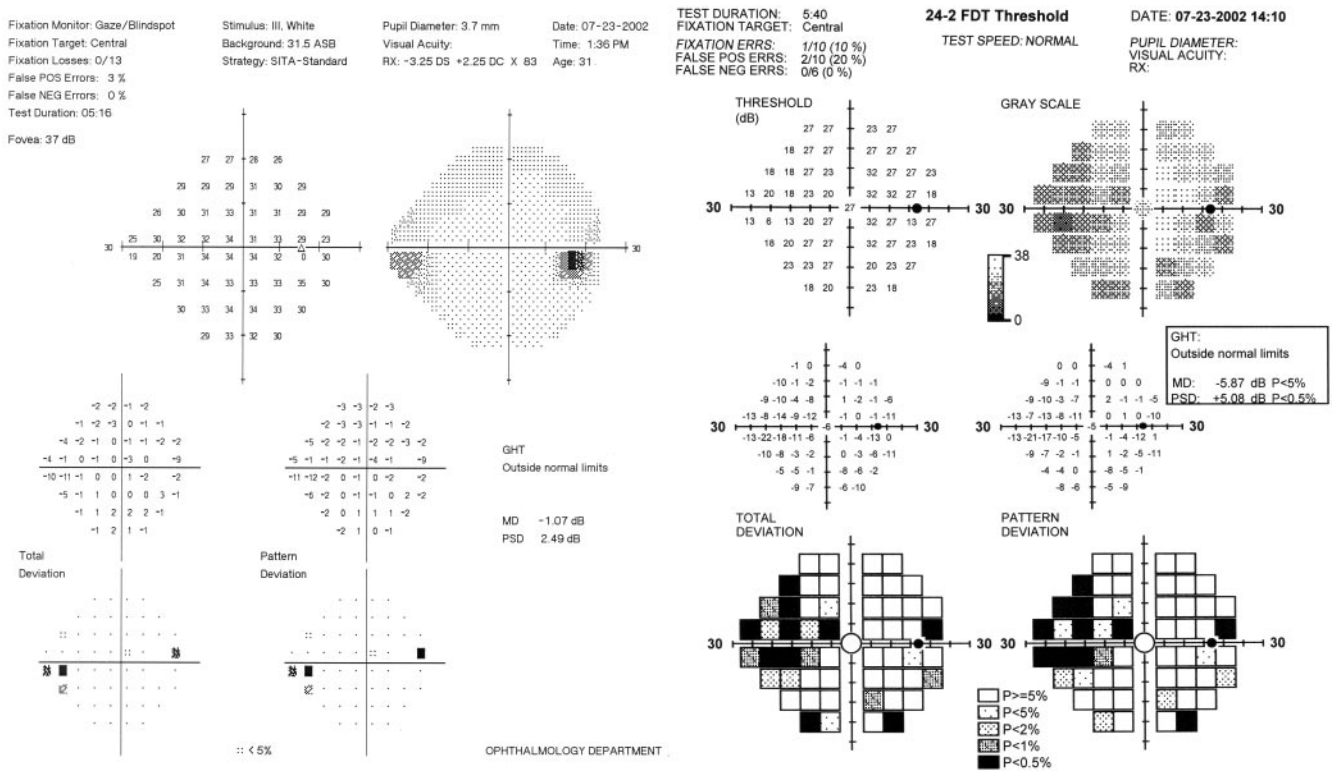


**FIGURE 5.** A 31-year-old subject with optic nerve head drusen in the right eye. The correlation score for both the total deviation and pattern deviation probability plots was poor. More extensive visual field loss was detected with Matrix testing for both the total deviation and pattern deviation probability plots.

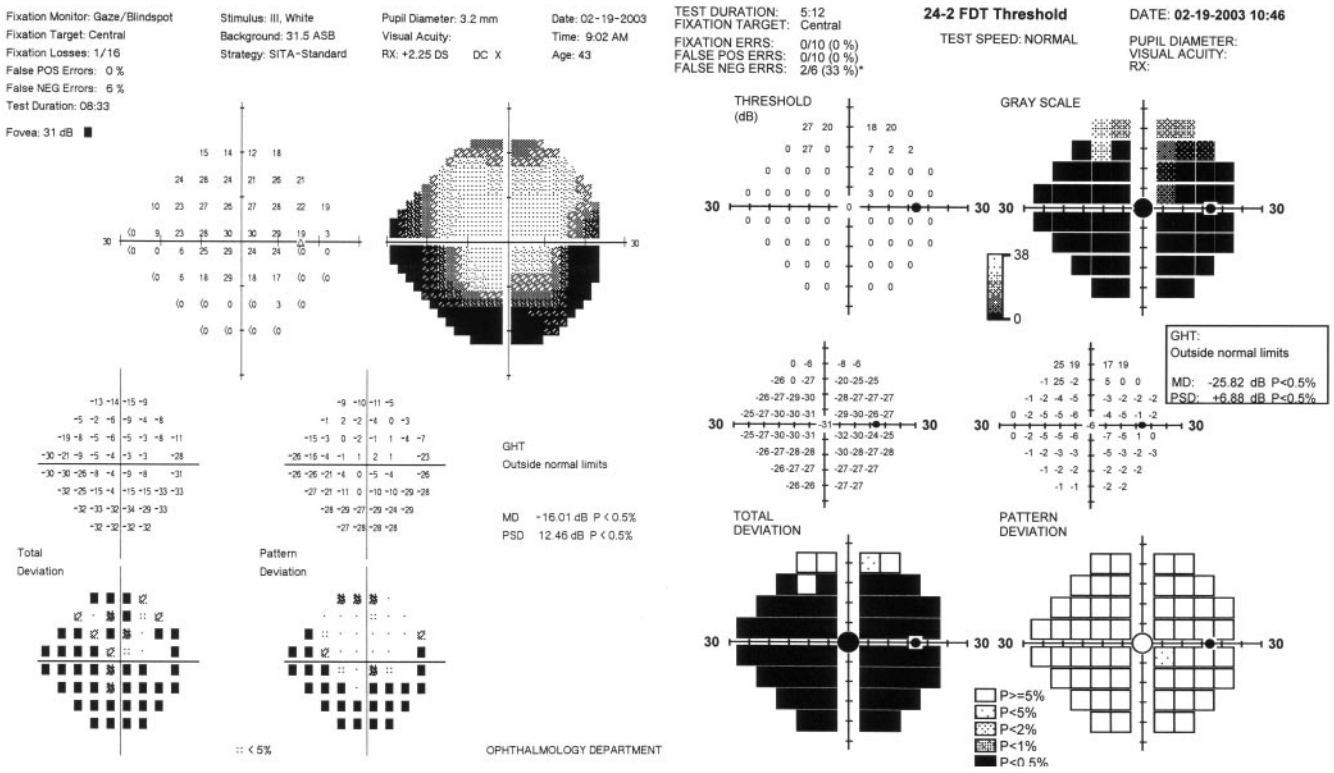


**FIGURE 6.** A 43-year-old subject with optic neuropathy in the right eye. The correlation score for the total deviation probability plot was good, whereas the pattern deviation probability plot was poor. An equivalent amount of visual field loss was demonstrated by both tests on the total deviation probability plots. More extensive visual field loss was detected with Humphrey SITA Standard 24-2 for the pattern deviation probability plots.

different visual field testing methods rather than to use the perimeters to establish a diagnosis, we did not exclude these patients with normal fields.

In summary, we found that the new Humphrey Matrix 24-2 testing strategy detected about as much visual field loss as the Humphrey SITA Standard 24-2 perimetry for optic nerve and chiasmal neuro-ophthalmic disorders. We conclude that Humphrey Matrix perimetry is approximately equal in sensitivity and specificity to the Humphrey SITA standard 24-2 perimetry. The new Humphrey Matrix 24-2 testing strategy provides a screening visual field testing method for optic nerve and chiasmal disorders that has fair to good correlation with the Humphrey SITA Standard 24-2 program. Both tests give acceptable results with regard to detection of optic nerve and chiasmal disorders.

## *References*

1. Maddess T, Goldberg I, Dobinson J, et al. Testing for glaucoma with the spatial frequency doubling illusion. *Vision Res*. 1999; 39(25):4258–4273.
2. White AJ, Sun H, Swanson WH, Lee BB. An examination of physiological mechanisms underlying the frequency-doubling illusion. *Invest Ophthalmol Vis Sci*. 2002;43(11):3590–3599.
3. Johnson CA. Selective versus nonselective losses in glaucoma. *J Glaucoma*. 1994;3(suppl):S33–S44.
4. Cello KE, Nelson-Quigg JM, Johnson CA. Frequency doubling technology perimetry for detection of glaucomatous visual field loss. *Am J Ophthalmol*. 2000;129(3):314–322.
5. Johnson CA, Samuels SJ. Screening for glaucomatous visual field loss with frequency-doubling perimetry. *Invest Ophthalmol Vis Sci*. 1997;38(2):413–425.
6. Quigley HA. Identification of glaucoma-related visual field abnormality with the screening protocol of frequency doubling technology. *Am J Ophthalmol*. 1998;125(6):819–829.
7. Anderson AJ, Johnson CA. Frequency-doubling technology perimetry. *Ophthalmol Clin North Am*. 2003;16(2):213–225.
8. Girkin CA, McGwin G Jr, DeLeon-Ortega J. Frequency doubling technology perimetry in non-arteritic ischaemic optic neuropathy with altitudinal defects. *Br J Ophthalmol*. 2004;88(10):1274–1279.
9. Sakai T, Matsushima M, Shikishima K, Kitahara K. Comparison of standard automated perimetry with matrix frequency-doubling technology in patients with resolved optic neuritis. *Ophthalmology*. 2007;114(5):949–956.
10. Wall M, Neahring RK, Woodward KR. Sensitivity and specificity of frequency doubling perimetry in neuro-ophthalmic disorders: a comparison with conventional automated perimetry. *Invest Ophthalmol Vis Sci*. 2002;43(4):1277–1283.
11. Anderson AJ, Johnson CA, Fingeret M, et al. Characteristics of the normative database for the Humphrey matrix perimeter. *Invest Ophthalmol Vis Sci*. 2005;46(4):1540–1548.
12. Keltner JL, Johnson CA, Beck RW, et al. Quality control functions of the Visual Field Reading Center (VFRC) for the Optic Neuritis Treatment Trial (ONTT). *Control Clin Trials*. 1993;14(2):143–159.
13. Keltner JL, Johnson CA, Cello KE, et al. Classification of visual field abnormalities in the ocular hypertension treatment study. *Arch Ophthalmol*. 2003;121(5):643–650.
14. Keltner JL, Johnson CA, Levine RA, et al. Normal visual field test results following glaucomatous visual field end points in the Ocular Hypertension Treatment Study. *Arch Ophthalmol*. 2005; 123(9):1201–1206.
15. Keltner JL, Johnson CA, Spurr JO, Beck RW. Baseline visual field profile of optic neuritis. The experience of the optic neuritis treatment trial. Optic Neuritis Study Group. *Arch Ophthalmol*. 1993;111(2):231–234.
16. Keltner JL, Johnson CA, Spurr JO, Beck RW. Visual field profile of optic neuritis: one-year follow-up in the Optic Neuritis Treatment Trial. *Arch Ophthalmol*. 1994;112(7):946–953.
17. Anderson DR, Patella VM. *Automated Static Perimetry.* 2nd ed. St. Louis: Mosby; 1999:152–153.